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(71) Applicant(s)
Robert Bosch GmbH

(Incorporated in the Federal Republic of Germany)

Wernerstrasse 1, Stuttgart-Feuerbach,
D-70442 Stuttgart 30, Federal Republic of Germany

(72) Inventor(s)
Juergan Binder
Martin Pfau
Eberhardt Schunck
Andreas Kaessmann

(74) Agent and/or Address for Service
A A Thornton & Co
Northumberland House, 303-306 High Holborn,
LONDON, WC1V 7LE, United Kingdom

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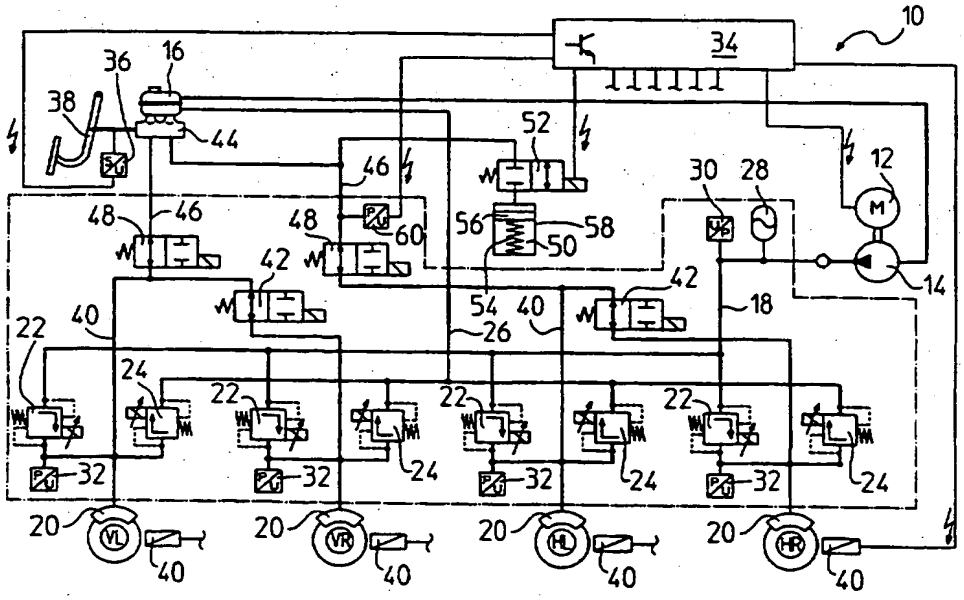
(54) Hydraulic brake system for a vehicle

(57) The hydraulic brake system comprises an accumulator 28 for normally supplying fluid to wheel brakes 20, a hydraulic pump 14 for recharging the accumulator, and identical inlet and outlet valves 22, 24 which are continuous-action pressure relief or continuous-action differential-pressure solenoid valves. During normal braking valves 48 are closed, a required braking force is sensed by a setpoint generator 36 or a pressure sensor 60, and "feel" is provided by a simulator 50. If the pump continues to operate due to a fault in ECU 34 or in sensor 30, the inlet and outlet valves will prevent the pressure exceeding a maximum. Failure of the ECU will result in direct transmission of fluid from the master cylinder 44 to the brakes 20. The system provides for anti-lock and traction control, for axle-specific pressure control using only one inlet and one outlet valve of each axle, and for load-dependent pressures for each axle.



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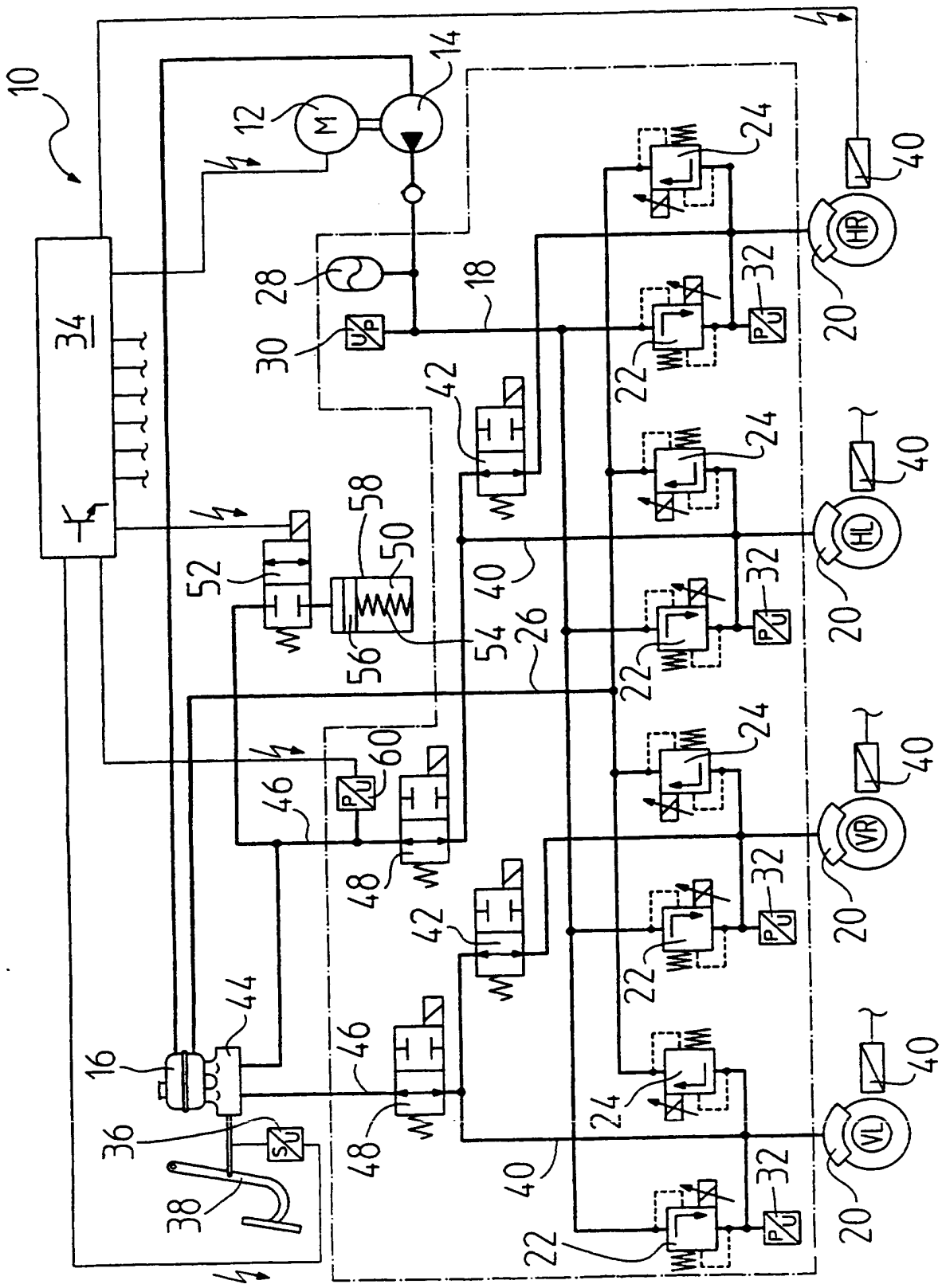

Description

Hydraulic, separately powered vehicle brake system

Background art

The invention proceeds from a hydraulic, separately powered vehicle brake system according to the type of the main claim.

Such a vehicle brake system is described in DE 195 48 207. Said vehicle brake system comprises a hydraulic pump drivable by means of an electric pump motor for building up a brake fluid pressure for the separately powered braking process. The hydraulic pump draws in from a brake fluid storage tank. Connected to a discharge end of the hydraulic pump are wheel brake cylinders, connected upstream of each of which is a solenoid inlet valve which is closed in its basic setting. Furthermore, connected downstream of each wheel brake cylinder is a solenoid outlet valve, which is open in its basic setting and is connected to the brake fluid storage tank. The solenoid valves are activated by an electronic control unit, which receives an input signal from an e.g. pedal-operated braking force setpoint generator and from brake pressure sensors connected to the wheel brake cylinders.

For the pressure build-up in the wheel brake cylinders the outlet valve is closed and the inlet valve opened up to adjustment in the wheel brake cylinders of a brake pressure dependent upon the signal of the braking force setpoint generator. For lowering the pressure in the wheel brake cylinders, the outlet valve is opened.

Besides its function of adjusting the brake pressure in the wheel brake cylinders, the inlet valve has a safety function: if, as a result of a fault in the electronic control unit or in a pump pressure sensor connected to the discharge end of the hydraulic pump, the brake fluid pressure exceeds an admissible maximum pressure, the inlet valve, which closes under the action of a spring, opens so that brake fluid flows from the discharge end of the hydraulic pump, through the inlet valve and the outlet valve which is open in its basic setting, back to the brake fluid storage tank so that the maximum pressure in the vehicle brake system is limited. During said process, no brake pressure is built up in the wheel brake cylinder.

Advantages of the invention

The inlet and outlet valves of the hydraulic, separately powered vehicle brake system according to the invention are of an identical design. This has the advantage of a larger piece number of identical valves and a lower number of valves of differing type, resulting in cost benefits. A further advantage is a reduced incidence of assembly errors because a mix-up of inlet and outlet valves during assembly is ruled out because of their identical design.

The inlet and outlet valves of the vehicle brake system according to the invention are moreover designed as pressure relief valves or differential-pressure valves so that the inlet valves serve as safety valves which limit the brake fluid pressure at the discharge end of the hydraulic pump to an admissible maximum pressure and hence protect the vehicle brake system from damage.

Advantageous developments and improvements of the hydraulic, separately powered vehicle brake system indicated in claim 1 are the subject matter of the sub-claims.

The inlet and the outlet valves according to claim 2 preferably take the form of continuous-action valves, which have a cross section of passage dependent upon their control or excitation current, i.e. restrict the passage of fluid in dependence upon their energization. This has the advantage that the pressures in the wheel brake cylinders are adjustable in a finely proportionable manner. Furthermore, an abrupt development of a brake fluid flow upon opening and an abrupt interruption of the brake fluid flow upon closing of the valves, which cause sudden pressure variations, are avoided. Such sudden pressure variations lead to undesirable noise generation, place the vehicle brake system under substantial stress as a result of pressure peaks and impair the quality of regulation of the wheel brake cylinder pressure during braking.

Drawing

There follows a detailed description of an embodiment of the invention which is illustrated in the drawing. The single drawing shows the hydraulic diagram of a vehicle brake system according to the invention.

Description of the embodiment

The separately powered brake vehicle brake system 10 according to the invention, which is shown in the drawing, comprises a hydraulic pump 14, which is drivable by means of an electric pump motor 12 and of which the inlet side is connected to a brake fluid storage tank 16. Connected by a branching main brake line 18 to a discharge end of the hydraulic pump 14 are four wheel brake cylinders 20, upstream of each of which an inlet valve 22 is connected. Connected downstream of each of the wheel brake cylinders 20 is an outlet valve 24, a common return line 26 leading from said outlet valves back to the brake fluid storage tank 16. The

inlet valves 22 and the outlet valves 24 are identically designed as continuous-action differential-pressure solenoid valves. They may be replaced by continuous-action pressure relief solenoid valves (not shown).

The vehicle brake system 10 according to the invention further comprises a separate energy store 28 in the form of a hydraulic accumulator connected to the discharge end of the hydraulic pump 14, a pump pressure sensor 30 likewise connected to the discharge end of the hydraulic pump 14 as well as brake pressure sensors 32 connected to each wheel brake cylinder 20.

Activation of the pump motor 12 as well as of the inlet and outlet valves 22, 24 is effected by an electronic control unit 34, which receives signals from the pump pressure sensor 30, from the brake pressure sensors 32 and from a braking force setpoint generator 36 which is adjustable by means of a brake pedal 38.

Operation of the separately powered vehicle brake system according to the invention

The hydraulic pump 14 delivers brake fluid into the separate energy store 28 until the pressure measured by the pump pressure sensor 30 attains a maximum pressure which is below an admissible maximum pressure of the vehicle brake system 10. Upon attainment of the maximum pressure, the hydraulic pump 14 is switched off. When the pressure in the separate energy store 28 falls below a minimum pressure which guarantees an adequate braking force when the inlet valves 22 are opened, the hydraulic pump 14 is switched back on and the separate energy store 28 is filled once more up to the maximum pressure.

The hydraulic pump 14 is therefore used to recharge the separate energy store 28

which permanently provides brake fluid under a sufficiently high pressure for braking. The separate energy store 28 has the advantage that there is always - i.e. even when the hydraulic pump 14 is switched off - a supply of brake fluid under pressure immediately available for braking. A further advantage is that the brake fluid pressure is relatively constant and pressure variations and pressure peaks are reduced. Pressure variations during the delivery of brake fluid which are caused by the style of construction of the hydraulic pump 14 are likewise compensated.

In their non-energized basic setting, the inlet valves 22 isolate the wheel brake cylinders 20 from the separate energy store 28. When, as a result of an adjustment of the braking force setpoint generator 36, a braking force build-up is required, the inlet valves 22 are energized and so pressure is built up in the wheel brake cylinders 20. The pressure in the wheel brake cylinders 20 is measured by the brake pressure sensors 32 connected thereto and adjusted by the inlet and outlet valves 22, 24, which are designed as continuous-action valves, to a value dependent upon the signal of the braking force setpoint generator 36, the brake pressure in each wheel brake cylinder 20 being individually adjustable. Preferably, the pressure in the wheel brake cylinders 20 of a vehicle axle is individually adjusted identically and load-dependently for each vehicle axle.

Besides their function of adjusting the wheel brake cylinder pressure, the inlet valves 22, which like the outlet valves 24 are designed as differential-pressure or pressure relief valves, also have a safety function: they are designed so as to open when a differential pressure acting upon them, or the pressure at their inlet side attains an admissible maximum pressure of the vehicle brake system. It is ensured that the pressure in the vehicle brake system 10 does not exceed the admissible maximum pressure if, as a result of a fault in the electronic control unit 34 or the pump pressure sensor 20, the hydraulic pump 14 continues to deliver after

attainment of the maximum pressure at which the pump is normally switched off.

When one of the inlet valves 22 opens as a result of attainment of the admissible maximum pressure, the outlet valve 24 is opened through energization in order to prevent brake pressure from building up in the wheel brake cylinder 20, i.e. in order not to brake the respective vehicle wheel. The opening of the outlet valve 24 is effected automatically in that the brake pressure sensor 32 detects a pressure build-up in the wheel brake cylinder 20 but the braking force setpoint generator 36 does not call for a build-up of braking force. A second possibility is to open the outlet valves continuously through energization so long as no build-up of braking force is called for by the braking force setpoint generator 36.

Slip control device

The separately powered vehicle brake system 10 according to the invention comprises wheel rotation sensors 40, the signals of which are supplied to the electronic control unit 34. When at one vehicle wheel there is a tendency to lock during braking or slip during acceleration, which the electronic control unit 34 detects by means of the wheel rotation sensors 40, a brake pressure modulation is effected in a known per se manner through activation of the inlet and outlet valve 22, 24 of the wheel brake cylinder 20 of the relevant vehicle wheel.

The wheel brake cylinders 20 of the vehicle wheels of a vehicle axle are connected to one another by a connecting line 40, in which a connecting valve 42 is disposed. The connecting valve 42 is a 2/2-way solenoid valve, which is open in its basic setting and is likewise activated by the electronic control unit 34. The connecting line 40 firstly has the advantage that in the wheel brake cylinders 20 of the vehicle wheels of a vehicle axis the same pressure is adjusted and enables an axle-specific

pressure build-up in the wheel brake cylinders 20 using only one inlet and one outlet valve 22, 24. The brake pressure in the wheel brake cylinders 20 may therefore be proportioned very finely. A further advantage is that, in the event of failure of an inlet or outlet valve 22, 24, it is nevertheless possible for both vehicle wheels of a vehicle axle to be braked using the inlet and outlet valve 22, 24 of the wheel brake cylinder 20 of the other vehicle wheel of said vehicle axle. The operational reliability of the vehicle brake system 10 according to the invention is therefore increased. For traction control, the connecting valve 42 is closed so that a wheel-specific pressure modulation in the wheel brake cylinders 20 may be effected.

Auxiliary braking device

In addition to its described service braking device, the vehicle brake system 10 is also equipped with an auxiliary braking device. The latter comprises a twin-circuit main brake cylinder 44 which is operable by means of the pedal 38 used to adjust the braking force setpoint generator 36. The brake fluid storage tank 16 is mounted onto the main brake cylinder 44. Use is therefore made of a conventional twin-circuit main brake cylinder 44 with top-mounted braking fluid storage tank 16, which is operated by means of the pedal 38, i.e. an assembly group of the type which is fitted in a great many motor vehicles. A braking force setpoint value is derived by the braking force setpoint generator 36 from the position of the pedal 38. The main brake cylinder 44 may be equipped with a known braking force booster, which is not shown in the drawing. Also, for the auxiliary braking device, a single-circuit main brake cylinder (not shown) is sufficient.

An auxiliary brake line 46 leads from each of the two brake circuits of the main brake cylinder 44 to the connecting line 40 of the wheel brake cylinders 20 of the

vehicle wheels of the front axle shown on the left in the drawing and of the rear axle shown on the right in the drawing, i.e. the vehicle wheels of the front axle are connected to the one brake circuit and the vehicle wheels of the rear axle to the other.

Disposed in each of the auxiliary brake lines 46 is an isolating valve 48. The isolating valve 48 is a 2/2-way solenoid valve which is open in its basic setting. Said valve is closed during braking with the above-described, separately powered service braking device, i.e. the main brake cylinder 44 is isolated from the wheel brake cylinders 20 and therefore does not influence the separately powered service braking process. In order to achieve a conventional force/travel response of the pedal 38 when the isolating valves 48 are closed, i.e. in order to convey to a driver the customary pedal response during braking and at the same time enable adjustment of the braking force setpoint generator 36 by means of the pedal 38, a known per se pedal travel simulator 50 is connected by a simulator valve 52 to one brake circuit of the main brake cylinder 44. The simulator valve 52 is a 2/2-way solenoid valve, which is closed in its basic setting and opened by the electronic control unit 34 during braking with the separately powered service braking device. The pedal travel simulator 50 comprises a piston 56 loaded by a spring 54 in a cylinder 58. When the main brake cylinder 44 is operated and the simulator valve 52 opened, brake fluid flows into the pedal travel simulator 50 so that the pedal 38 may be depressed. The spring 54 produces in the brake fluid a pressure which rises with increasing compression of the spring 54, so that the force for depressing the pedal 38 continuously increases in the customary manner for muscular power brakes or servo-brakes.

In the event of failure of the separately powered braking device, the isolating valves 48 inserted between the main brake cylinder 44 and the wheel brake

cylinders 20 move into their open basic setting, as do the connecting valves 42 disposed in the connecting lines 40, so that the wheel brake cylinders 20 are connected to the main brake cylinder 44. The simulator valve 42 moves into its closed basic setting so that the pedal travel simulator 50 is isolated from the main brake cylinder 44. Braking with the auxiliary braking device is effected in a manner operated by muscular power, optionally assisted by auxiliary force by means of a braking force booster by depressing the pedal 38.

Connected to the main brake cylinder 44 is a pressure sensor 60, the signal of which is supplied to the electronic control unit 34. The pressure sensor may be used, in addition to or instead of the braking force setpoint generator 36, to adjust the pressure in the wheel brake cylinders 20 during braking with the separately powered service braking device.

The connecting line 40 between the wheel brake cylinders 20 of the vehicle wheels of a vehicle axle offers the benefit of an advantageous connection possibility of the auxiliary braking device. An advantage of the connecting line 40 and auxiliary brake line 46 connecting the wheel brake cylinders 20 to the main brake cylinder 44 is the indirect connection of the wheel brake cylinders 20 by the main brake cylinder 44 to the brake fluid storage tank 16. Thus, brake fluid in the safety function of the inlet valve 22, when the latter opens upon attainment of the admissible maximum pressure at the discharge end of the hydraulic pump 14, may flow through the connecting line 40, optionally the open connecting valve 42, the open isolating valve 48, the auxiliary braking device 46 and the main brake cylinder 44 back into the brake fluid storage tank 16 without the outlet valve 24 having to be operated. Thus, without intervention of the electronic control unit 34 an undesirable pressure build-up in the wheel brake cylinder 20 is reliably avoided. When the vehicle brake system 10 is provided without an auxiliary

braking device and hence without a main brake cylinder 44, the wheel brake cylinders 20 may be connected by the connecting line 40 and the isolating valve 48 alternatively directly to the brake fluid storage tank 16 so that, upon a response of the inlet valve 22 in its safety function, the outlet valve 24 does not have to be operated.

Claims

1. Hydraulic, separately powered vehicle brake system having a hydraulic pump, of which the inlet side is connected to a brake fluid storage tank and the discharge end is connected to wheel brake cylinders, a starting valve being connected upstream of each wheel brake cylinder, having outlet valves by which the wheel brake cylinders are connected to the brake fluid storage tank, and having an electronic control unit, which receives electrical control signals from an adjustable braking force setpoint generator and from brake pressure sensors connected to the wheel brake cylinders and which activates the inlet valves and the outlet valves in such a way that a brake pressure dependent upon the signal of the braking force setpoint generator is adjusted in the wheel brake cylinders, **characterized in** that the inlet valves 22 and the outlet valves 24 are identically designed pressure relief or differential-pressure solenoid valves.

2. Hydraulic, separately powered vehicle brake system according to claim 1, **characterized in** that the inlet valves 22 and the outlet valves 24 are continuous-action valves.

3. Hydraulic, separately powered vehicle brake system according to claim 1 or 2, **characterized in** that a hydraulic accumulator 28 is connected to the discharge end of the hydraulic pump 14.

4. Hydraulic, separately powered vehicle brake system according to

one of claims 1 to 3, **characterized in** that the wheel brake cylinders 20 of a vehicle axis are connected by a connecting valve 42 to one another.

5. Hydraulic, separately powered vehicle brake system according to one of claims 1 to 4, **characterized in** that the vehicle brake system 10 comprises an auxiliary braking device with a main brake cylinder 44, to which the wheel brake cylinders 20 are connected by an isolating valve 48.

6. Hydraulic, separately powered vehicle brake system according to claim 5, **characterized in** that a pedal travel simulator (50) is connected to the main brake cylinder 44.

7. Hydraulic, separately powered vehicle brake system according to one of the preceding claims, **characterized in** that it comprises a traction control device.

8. A hydraulic separately powered vehicle brake system substantially as herein described with reference to the accompanying drawing.

The Patent Office

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Application No: GB 9716695.3 **Examiner:** Peter Squire
Claims searched: 1-7 **Date of search:** 21 October 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2F FC FFE

Int Cl (Ed.6): B60T 8/32, 34, 36, 40 13/68

Other: Online:EDOC,WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	WO 97/23372 A1 (Bosch)	
A	WO 97/21573 A1 (Bosch)	
A	US 4435021 (Lucas)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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